

Our problems are man-made, therefore they may be solved by man.

John F. Kennedy (1917–1963)

MERCURY

Cleanup for Broken CFLs

Compact fluorescent lamps (CFLs) are about 75% more energy efficient than incandescent light bulbs and last 10 times longer, and thus have quickly become a modern-day environmental icon. The U.S. Environmental Protection Agency (EPA) estimates that about 290 million CFLs were sold in 2007. But CFLs do have one dim spot on their otherwise bright green image: the mercury that makes the bulbs' inner phosphor coating fluoresce and produce light. A new study from a group of researchers at Brown University characterizes for the first time how elemental mercury vapor escapes from broken CFLs and offers a real-world solution for capturing escaping mercury.

According to a June 2008 fact sheet issued by the EPA Energy Star program, the use of CFLs results in a net reduction in mercury entering the environment because their lower energy draw means less mercury-emitting coal needs to be burned. The EPA estimates that using a 13-W CFL saves 376 kWh over its 8,000-hour lifespan, preventing 4.5 mg of mercury from being emitted by a coal-burning power plant. Each small, curly tube contains about 3–5 mg of mercury—significantly less than the 500 mg in older thermometers,

but enough that environmental and human health concerns remain.

The research group headed by Robert Hurt, director of the Institute for Molecular and Nanoscale Innovation, broke a series of new and used CFLs to measure the release of mercury vapor into the air. In the hour immediately after each breakage, the team recorded mercury gas concentrations near the bulb shards between 200–800 $\mu\text{g}/\text{m}^3$. For comparison, the average 8-hour occupational exposure limit allowed by the Occupational Safety and Health Administration is 100 $\mu\text{g}/\text{m}^3$. Within 4 days a new 13-W CFL released about 30% of its mercury, with the remainder appearing to remain trapped in the bulb debris; picking up the glass shards after breakage reduced mercury release by 67%. Used bulbs followed similar patterns but with lower rates. The study, which was funded by the NIEHS Superfund Basic Research Program, was reported in the 1 August 2008 issue of *Environmental Science & Technology*.

"The amount of mercury gas coming off [broken CFLs] is over a milligram over a few days. If you put that milligram into a poorly ventilated room, the concentration can be over the recommended limit for children [of 0.2 $\mu\text{g}/\text{m}^3$]," says Hurt. "The overall risk is low, but it's not zero risk, and there is definitely an opportunity to do better."

This kind of information could help regulators provide better information on how to handle broken CFLs. In 2007 the Maine Department of Environmental Protection performed one of the only other studies evaluating mercury exposure from broken CFLs. The EPA's current recommendation to leave the room for

at least 15 minutes immediately after breaking a CFL derives from that study. The EPA also recommends that broken CFL pieces be scooped up and placed in a plastic bag.

However, Hurt's research suggests that the peak for escaping mercury vapor lasts a few hours. The group also found that plastic bags leaked mercury vapor. "This new information may allow for modeling of airborne mercury concentrations following breakage, thus providing the capability to more fully assess the effectiveness of cleanup," says Roxanne Smith, a press officer for the EPA.

Hurt's group also tested 28 sorbents for their ability to capture the released mercury gas. Because a sorbent's surface area can affect how well it captures mercury, the team chose to test nanoscale formulations, which provide large surface area. One type of nanoselenium was found to be the most effective, removing 99% of the mercury vapor when impregnated in a cloth that was draped over a broken CFL or sprinkled over the breakage as a powder. When the mercury vapor reacted with nanoselenium, it formed mercury selenides, which are insoluble and metabolically inactive, according to a report in the November 2004 issue of the *Seychelles Medical and Dental Journal*. These compounds are also believed to be stable under landfill conditions (with the caveat that the environmental disposition and health effects of nanomaterials are still largely unknown).

There are CFL recycling programs across the country at major retailers such as The Home Depot, but the Association of Lighting and Mercury Recyclers estimates that 98% of CFLs currently end up in landfills. Hurt's group has therefore developed prototype packaging and disposal bags that can act as a barrier to prevent mercury from escaping as well as neutralize it. "Development of technology or material to more effectively clean up or capture mercury vapor may potentially minimize worker exposures during transport and disposal and, if readily available to consumers, may potentially minimize future inhalation exposures in residential settings," says Smith. — Graeme Stemp-Morlock



Nanoselenium (inset) may be one answer to the question of how to safely clean up mercury from broken CFLs



Kristina May, inset: Brown University, courtesy of R. Hurt

BUILT ENVIRONMENT

New Default for Asphalt?

The vast majority of the nearly 2 million miles of paved roads in the United States are surfaced with asphalt pavement, which is made by combining a thick hydrocarbon mixture known as liquid asphalt binder with sand, gravel, or crushed stone ("aggregate"). Each year about 60 million tons of hot-mix asphalt (HMA) pavement are laid on U.S. roads, according to figures presented last



Cooler asphalt offers one route to more sustainable road building

spring at the 12th Annual Minnesota Pavement Conference. Asphalt pavement is tough, flexible, and easy to repair, but the commonly used HMA is energy-intensive to produce, releases greenhouse gases, and poses potential hazards for workers. So researchers are looking at lower-temperature asphalt pavements as a way around these problems.

Warm-mix asphalt (WMA) can be used at temperatures of 212–284°F, about 50–100°F cooler than HMA, while cold-mix asphalt (CMA) is used at ambient temperatures. Both can be produced with minimal modifications to HMA plants, says University of Wisconsin–Madison civil and environmental engineering professor Hussain Bahia.

In paving workers, inhalation of asphalt fumes can irritate the nose, throat, and lungs, as well as cause excessive fatigue and loss of appetite, according to the National Institute for Occupational Safety and Health. A study in the November 2004 issue of the *Annals of Occupational Hygiene* cited dermal and inhalational exposure of paving workers to polycyclic aromatic compounds, which have been labeled as reasonably anticipated to be human carcinogens by the National Toxicology Program. But whereas certain extracts of asphalt have caused a carcinogenic skin response in experimental animals, research to date has found no conclusive evidence of increased risk of skin or lung cancer in workers.

HMA plants use petrofuels to heat the liquid asphalt binder to a workable temperature as well as dry and heat the aggregate to

improve cohesion. "You inevitably have . . . the resultant emission of typical fuel combustion by-products like sulfur dioxide, carbon monoxide, carbon dioxide, volatile organics, and other substances, similar to a home heating furnace," says Gary Fore, vice president for environment, health, and safety at the National Asphalt Pavement Association (NAPA), a trade association. "That's why we're continuing to explore lower-temperature alternatives."

In the September 2007 *Europeanroads Review*, Pierre Dorchie and colleagues wrote that CMA technology could afford a 30% energy saving over traditional HMA. NAPA president Mike Acott says, "The challenge with cold mix is to produce a surface as strong and reliable as hot mix, and there are some factors getting in the way. Cold mix is not generally used as a surfacing material and certainly not for roads subjected to medium to heavy traffic." CMA is used in countries such as South Africa and

India, where there is relatively little heavy traffic, and to a lesser degree in the United States.

The issue, Acott says, "is to produce materials that perform as well as hot mix for the U.S. road infrastructure. That's where we believe warm mix comes in. Our research indicates that warm mix can produce a surface laid down at a substantially lower temperature [that performs] as well as hot mix."

The 2007 NAPA report *Warm-Mix Asphalt: Best Practices* says a shift from HMA to WMA in Norway, Italy, the Netherlands, France, and Canada has yielded significant emissions reductions. Adoption of WMA in these nations is being driven largely by Europe's participation in the Kyoto Protocol and implementation of the new Registration, Evaluation, Authorisation and Restriction of Chemical Substances (REACH) legislation, according to an article in the 14 April 2008 issue of *Michigan Contractor and Builder*. WMA shows signs of being as good as or better than HMA, but with a track record of only about 10 years, it hasn't yet had time to prove itself in real-world settings. More data should be forthcoming: in 2008 the Asphalt Institute was awarded a \$900 million 3-year grant by the Transportation Research Board of the National Academies to compare elements of WMA and HMA including performance and emissions.

Peter Grass, president of the Asphalt Institute, another trade association, says several projects using WMA are under way in the United States, including plans this year to

eHPnet | by Erin E. Dooley

PAHO Communicable Disease Unit

<http://www.paho.org/english/ad/dpc/dpc-page.htm>

The Pan American Health Organization (PAHO), an international public health agency, supports a Communicable Disease Unit (CD) whose primary functions include building networks and mobilizing resources for the prevention and control of communicable diseases; providing national and local training in areas such as clinical case management and use of standard guidelines for prevention and control activities; promoting and coordinating research; and developing policies, plans, and guidelines. Information collected by the CD is available through the top menu bar of PAHO's Health Surveillance and Disease Prevention and Control website.

Besides information on diseases such as cholera, acute respiratory infections, and anthrax, the website provides information on mosquito-borne diseases such as dengue, malaria, West Nile virus, and yellow fever. Sections on each disease link to resources for disease surveillance, reports on the history of each disease, profiles of the disease in countries where it is occurring, and statistics on incidence and mortality. Each section also links to any available epidemiological surveillance systems and to laboratory networks established by PAHO for each disease. Visitors will also find resources for prevention, control, and educational efforts, including field guides, materials for families and communities, policy documents, overviews of global disease control strategies, travel advisories, journal articles, and bibliographic databases.

lay more than 1 million tons of WMA in Texas alone. The Massachusetts Port Authority Board has also just authorized \$6.3 million to repave a runway at Boston Logan International Airport with WMA, making Logan the first U.S. airport to use the more environmentally friendly surface. In a 24 July 2008 press release, Port Authority Board CEO and executive director Thomas J. Kinton Jr. said, "Warm mix uses 20% less energy to make, produces 20% fewer greenhouse emissions when applied, and allows us to use a higher percentage of recycled asphalt pavement in the final product."

There is still a lot of research to be done before all the questions are answered and issues settled about CMA, a point with which Bahia agrees. Within his newly established Modified Asphalt Research Center, Bahia is exploring what it will take to make CMA a recognized replacement for HMA, including the possible addition of polymers or plastics to yield a quieter, safer, more durable pavement. Bahia says "Some 80% of the roads in this country are low-traffic-volume roads. Those are the applications where we believe cold mix would be appropriate. As energy prices continue to rise, taking asphalt prices along, we're going to be forced to consider alternatives." —Lance Frazer

LEGISLATION

Solar Tax Credit Loses Energy

The solar investment tax credit (ITC), created by the Energy Policy Act of 2005, allows those who invest in solar technology to deduct 30% of the purchase and installation costs incurred during the year from their taxable income. Although it's been a boon for home and small business owners who can quickly install photovoltaic (PV) solar panels, water heaters, and other technologies, the ITC hasn't provided comparable benefits to much larger solar power plants that could supply grid electricity to homes and businesses throughout the United States—a state of affairs that may be prolonged by political bickering.

In a technology known as concentrating solar power (CSP), arrays of reflective mirrors spread over hundreds of acres collect and focus the sun's heat to make steam that, in turn, creates electricity by running a turbine engine. A total of 10 CSP plants built in sun-drenched regions of California and Nevada during the 1980s—plus a 1-MW demonstration plant in Arizona—already power more than 300,000 homes at a cost of roughly 15¢ per kWh, comparable to standard rates in many U.S. locations. Electric utilities in those states, and also in Florida and Hawaii, have agreed to purchase 4,500 MW of additional solar-generated electricity from a total of 16 planned CSP facilities, which could power up to 3.5 million American homes.

But before investors will fund those projects, they want to be sure ITC tax breaks will be available throughout plant construction. A typical CSP plant takes 4–6 years to build, explains Nate Blair, a senior energy analyst with the Department of Energy National Renewable Energy Laboratory. Congressional officials have proposed eight-year extensions to the ITC that would boost the entire solar industry while also making CSP costs more predictable in the long term. Those proposals are contained in two bills that are currently stalled in the Congress: HR 6049, which has been passed by the House of



Nevada Solar One CSP plant
Boulder City, Nevada

Representatives but not the Senate, and the Senate's counterpart, S 3335, which has yet to be passed by either legislative chamber.

According to Carol Werner, executive director of the Environmental and Energy Study Institute, a Washington, DC, think tank, investors need to be assured the ITC will be available for each year of construction so they can negotiate prices in advance for the power they sell. Until an extension long enough to cover construction timelines emerges, she says, these projects will remain in limbo.

"This is a big deal [because it] affects manufacturers' and installers' capacity decisions," adds Justin Baca, a senior research analyst with the Solar Energy Industries Association (SEIA), a trade group. "An eight-year extension of the ITC . . . [is] much more effective than a series of short-term renewals."

Working with congressional supporters on both sides of the aisle, the solar industry has tried since 2006 to pass an eight-year ITC extension. Monique Hanis, director of communications for the SEIA, says Congress still can't agree on how to cover the approximately \$1.5 billion cost—which is far less than the roughly \$40 billion in annual tax credits passed on to the fossil fuel industry (including coal, natural gas, and oil) every year. "Hopefully the Senate will pass one of the two bills later in the fall," Hanis says. Meanwhile, the ITC is set to expire at the end of 2008. —Charles W. Schmidt

Solar Energy Industries Association

The Beat by Erin E. Dooley

Declaration on Port Pollution

A 2008 UN Intergovernmental Panel on Climate Change report estimates the shipping industry produces nearly 4.5% of the CO₂ emitted worldwide and that these emissions will increase by 30% by 2020. Shipping emissions are not governed by the Kyoto Protocol, so in July 2008 a group of 55 port officials from 35 countries gathered at the World Ports Climate Conference where they signed the World Ports Climate Declaration, in which parties agree to cut their

CO₂ outputs, possibly by using cleaner-burning fuel, reducing travel speeds, and developing better ship coatings to reduce drag. At the meeting, representatives of the International Maritime Organization announced progress in developing new emissions targets for the shipping industry, to be implemented by 2010.

Keeping Apace with e-Waste

The import of electronic junk into developing countries for recycling or disposal threatens both environmental and human health. Although recycling computers yields valuable metals, improper handling also releases lead, mercury, and other potential toxicants into the environment. At the June 2008 meeting of the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and Their Disposal, parties launched a significant initiative to abate that threat: the Partnership for Action on Computing Equipment, or PACE. The partnership will establish international guidelines for environmentally sound methods of repairing and recycling computer goods, certify facilities that use such methods, and train workers in responsible practices. Parties to the Basel Convention must ensure that hazardous waste is managed in an environmentally sound manner.



Walk to School Month 2008

Each October community groups worldwide sponsor events that promote walking to school as a way of improving children's health, reducing traffic emissions, and enriching community life. In 2007 millions of walkers in 42 countries participated in such events; in the United States, almost 3,000 schools from all 50 states took part. Interested parties can read more about the International Walk to School program at <http://www.iwalktoschool.org/>, which includes tips for sponsoring events as well as educational materials for teachers, parents, and children.

Left to right: Robert Caughey/Shutterstock; Kelpfish/Shutterstock



ALTERNATIVE TEST MODELS

Ocular Safety Assays Accepted

In a significant step forward for alternative safety test methods designed to reduce, refine, or replace the use of live test animals, the Interagency Coordinating Committee on the Validation of Alternative Methods (ICCVAM) recently announced the regulatory acceptance of two new *in vitro* ocular safety assays by the U.S. Food and Drug Administration, Environmental Protection Agency, and Consumer Product Safety Commission. The acceptance was based on recommendations made by ICCVAM after an extensive evaluation of the methods.

The United States tallies an estimated 125,000 eye injuries in the home each year caused by accidental exposure to common household products such as bleach and oven cleaner, according to the American Academy of Ophthalmology. Proper identification and labeling of substances that can damage the eye is one way to combat such injuries. Several agencies require manufacturers to test new products for their potential to cause temporary or permanent blindness, irritation, or other eye injuries.

Working with the National Toxicology Program Interagency Center for the Evaluation of Alternative Toxicological Methods (NICEATM), ICCVAM evaluated and recommended the bovine corneal opacity and permeability (BCOP) and the isolated chicken eye (ICE) test methods—the first nonanimal ocular safety test methods to be accepted by the regulators. In both cases, the animal eyes used for the tests are slaughterhouse waste, so no animals are euthanized specifically to obtain these tissues. The assays have been in development since the early 1990s.

Now that the BCOP and ICE assays have earned regulatory acceptance, they must be considered as the first option for ocular safety testing under the Animal Welfare Act, which requires the consideration of alternative methods before animals are used for procedures

that may cause more than slight or momentary pain or distress. “If you get a positive result in either of these assays, you can use that as a positive for the purposes of classifying and labeling [a material] as a severe irritant,” says Marilyn Wind, chair of ICCVAM and a deputy associate executive director with the Consumer Product Safety Commission. “If it’s negative, then [manufacturers] have to go to the next step and test in animals. This eliminates the most corrosive and severe chemicals from having to be tested in animals, so there is a reduction in potential pain and distress.”

Although precise numbers are not available for the use of live animals in ocular testing, William Stokes, director of NICEATM and executive director of ICCVAM, estimates that based on the relative distribution of adverse effects, use of the two assays could reduce the use of live animals for eye safety testing by 10% or more. “The overall goal is to come up with an integrated testing strategy using several nonanimal tests that will accurately predict whether chemical products have the potential to damage the eye or not,” he says. ICCVAM and NICEATM are in the process of evaluating other *in vitro* methods for ocular safety, hoping to eventually eliminate altogether the need for *in vivo* testing in this realm.

In the near term, ICCVAM is working with its counterparts in Europe and Japan to expedite approval of the BCOP and ICE assays at the international level by the 30-member Organisation for Economic Co-operation and Development. This group includes the United States, Canada, Japan, and most of the European Union, where a ban on live animal testing of cosmetic ingredients takes effect in March 2009 and the newly implemented REACH (Registration, Evaluation, Authorisation and Restriction of Chemical Substances) legislation will require testing of thousands of chemicals by 2018. —Ernie Hood



Coast Guard workers distribute bottled water after Hurricane Katrina, 1 September 2005

Potable Water a Priority in Hurricane Preparedness

In July 2008 the Harvard School of Public Health released survey results on hurricane preparedness of more than 5,000 participants from eight coastal states, plus a special sample of New Orleans residents. Three years after Hurricane Katrina, people affected by the storm named the need for fresh drinking water as a top priority in a storm's aftermath, and 37% of participants reported keeping water purification supplies on hand. Some 34% of respondents affected by Katrina felt prepared if a major hurricane were to

strike their communities within the next 6 months. The Atlantic Ocean hurricane season runs each year from June 1 to November 30.

Skin Cancer Souvenir?

A population-based study of young, white British women published online 10 July 2008 ahead of print in the *Journal of Investigative Dermatology* suggests that vacationing—but not necessarily living—in hotter or higher-altitude locations than one's home is associated with a greater whole-body number of nevi (benign moles) in women aged 18–29 who normally live in temperate climates. The association was particularly strong for nevi on the trunk and lower limbs, which typically are only intermittently exposed to the sun. The researchers believe this finding supports the hypothesis that intermittent sun exposure is a primary environmental risk factor for developing nevi, and thus for melanoma. Having a large number of nevi is the strongest known risk factor for melanoma in whites.

The Health Impact of Incense

In Asian countries where Buddhism and Taoism are the major religions, incense is burned daily in homes and temples. A review published 25 April 2008 in *Clinical and Molecular Allergy* and a study published 9 May 2008 in *Chemico-Biological*

Interactions focus on the potential respiratory and carcinogenic effects of incense smoke, which can contain benzene, toluene, xylene, 1,3-butadiene, polyaromatic hydrocarbons, and particulate matter. The first study found that exposure to incense smoke can cause airway dysfunction, elevated cord blood IgE levels, allergic contact dermatitis, and neoplasms, and advises people to reduce exposure when they worship and to ventilate homes during the burning of incense. The second found that temple workers in Thailand had significantly more DNA damage and reduced DNA repair capacity, and warns that exposure to incense smoke may increase the risk of cancer.

